CNES Initiatives on AI

WGISS

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CENTRE NATIONAL D'ÉTUDES SPATIALES

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Automatic car counting

Motivations

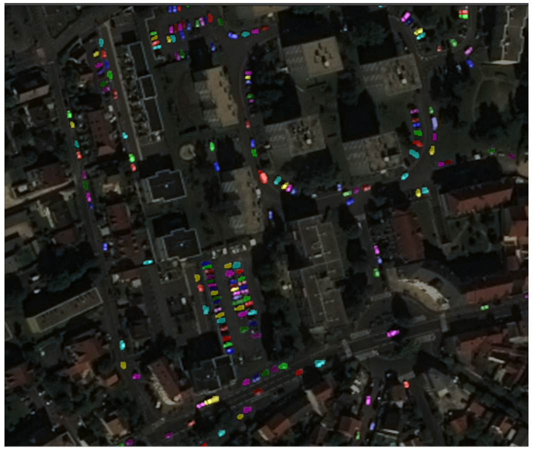
- Help companies to develop new applications using satellite images
- Elaborate remote sensing indicators to cross with other type of indicators to estimate economic health in different fields:
  - Car industry
  - Tourism
  - Mineral exploitation
  - ...
- Current work in collaboration with the company QUANTCUBE and the research lab IRISA.

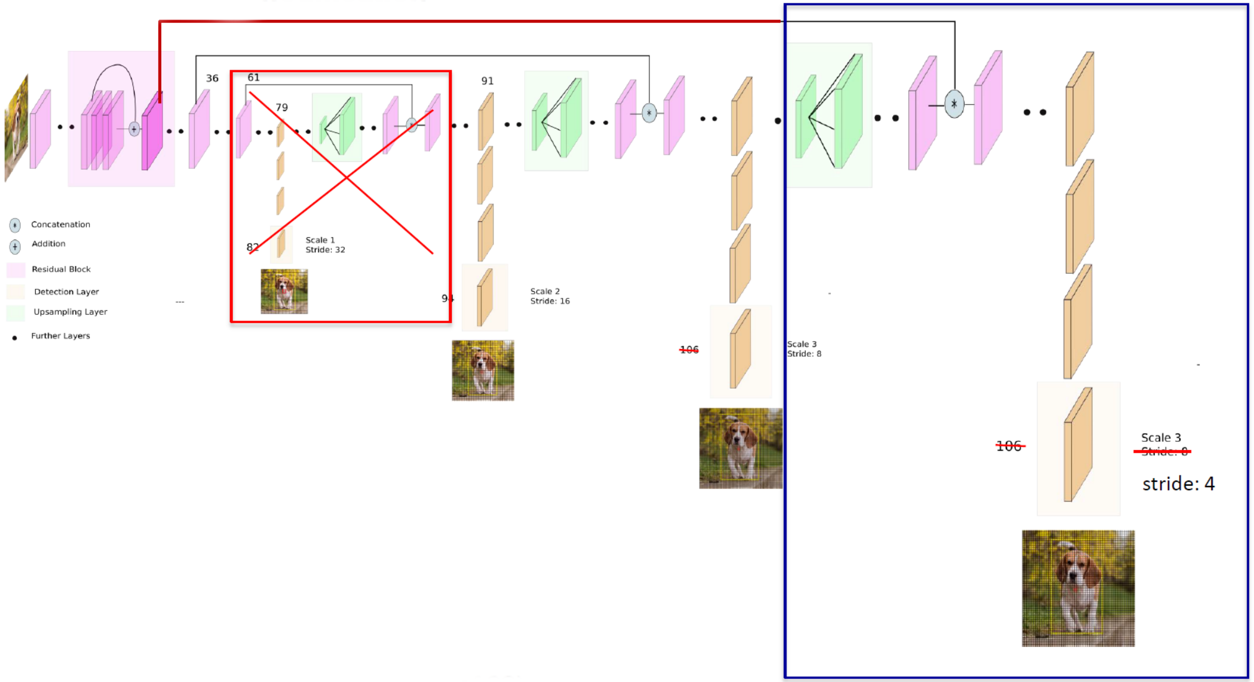
Challenges

- Build a predictive model able to detect cars on VHR Pleiades satellite images:
  - Cars are represented by small areas in the images (around 30 pixels on average)
  - Build training and test datasets from a set of orthorectified pansharpened orthorectified images over Paris.
- Cross the car number over interest areas with other indicators to predict economic trends in field of interest:
  - Define application and its need to have one-time or frequent observations of the interest areas
  - Data science methods to cross various indicators with the car numbers

Training

- Use of labelling tools based on segmentation algorithms to help building training and test datasets.





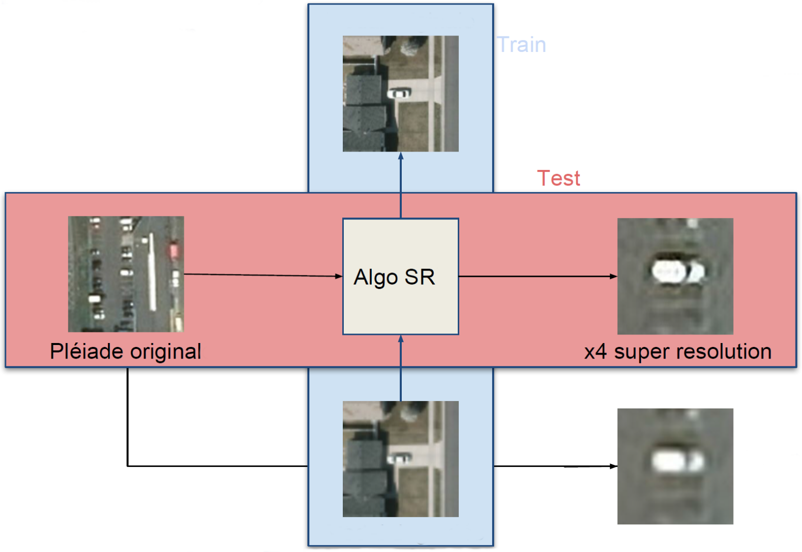
Current performance

Area Type	Accuracy
Downtown	58%
Area with large parkings and roads	75%
Countryside area	77%

- Difficulty to detect black cars
- Use post-processing to filter false positive detections by looking at local NDVI mean.

Improvement: Use super-resolution AI

- Enhance the car contours



Use cases proposed

- Detection of deserted urban areas.
- Monitor mining operations
- Monitor activities of commercial centers
- Estimation of hotel incomes with the following information:
  - Satellite images
  - Room prices
  - Job offers
  - Other alternative data

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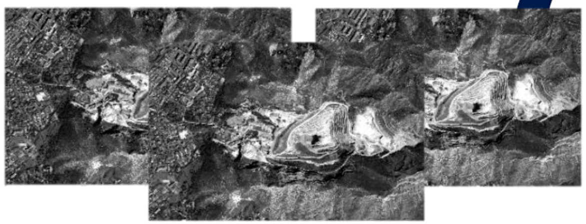
Automatic building detection from 3D data

Context

- Preparing the applications of the 3D data provided by the future mission CO3D:
  - Constellation of 2 or 4 VHR optical satellites looking at the same landscape at the same time
  - World DEM (Digital Elevation model) cover every year
  - S2P software used by CNES to generate DEM and cloud points from those stereo-images
  - Set of ortho images registered with DEM available: gain of the height information



Tri-Stéréo Pléiades (Calanques, Marseille)

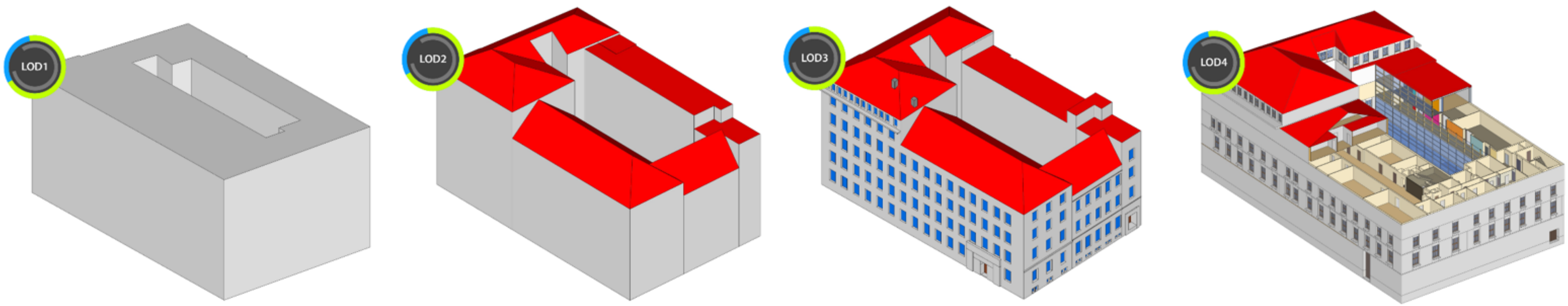
© CNES (2013), distribution Airbus DS/ Spot Image

Modèle **N**umérique de **S**urface (MNS)

Automatic building detection from 3D data

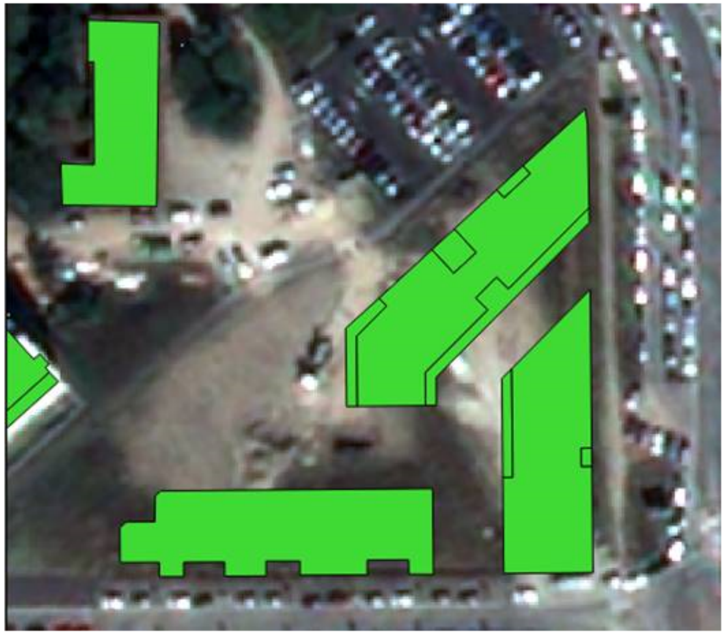
Objectives & Challenges

- Objectives
  - Monitor the urban areas (building changes) of cities
  - Elaborate high quality 3D products (Level of Details $\in [1; 3]$) by extrusion
- Challenges
  - Apply and adapt classical 2D machine learning algorithms on 3D point clouds (irregular data structures).
  - Creation of 3D training and test datasets

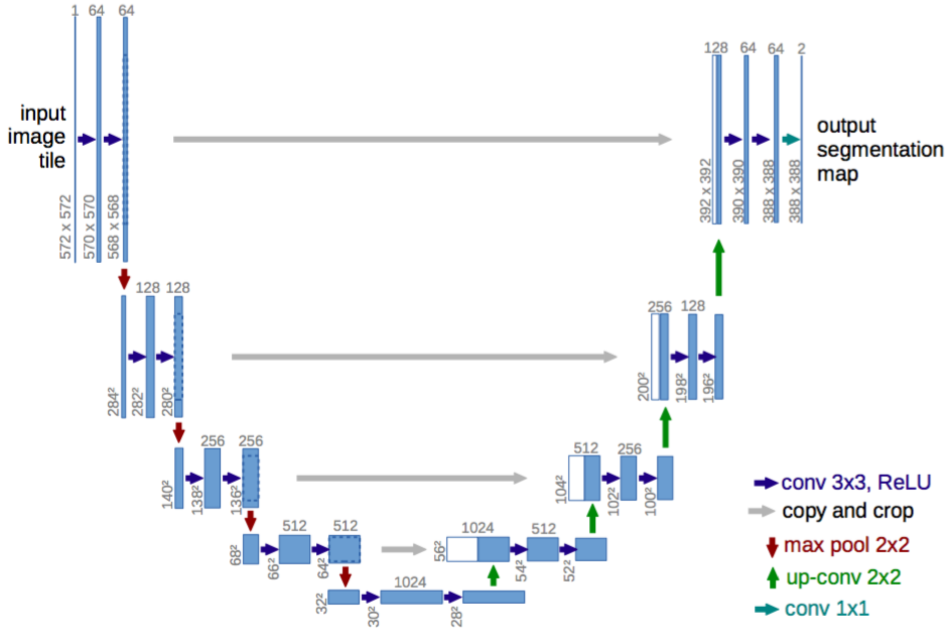


Training

- Ortho + DEM on Toulouse city area
- 14157 tiles for training dataset
- 6067 tiles for test dataset
- 2 classes: no-building (0) and building (1)
- Labelization made with OpenStreetMap
- 3-Fold stratified splitting strategy

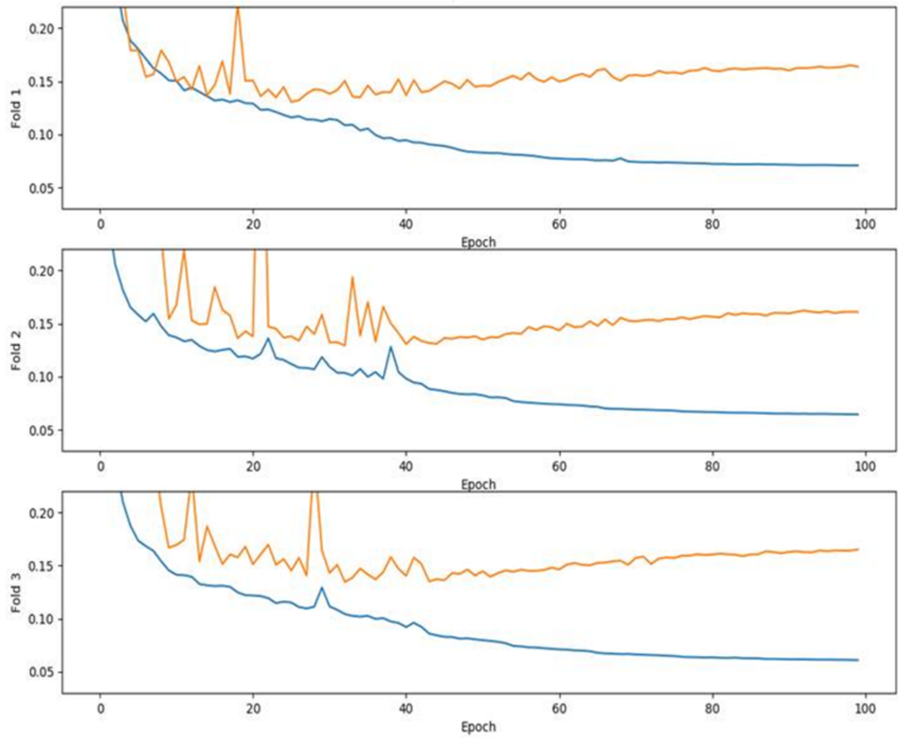


- Classical U-Net

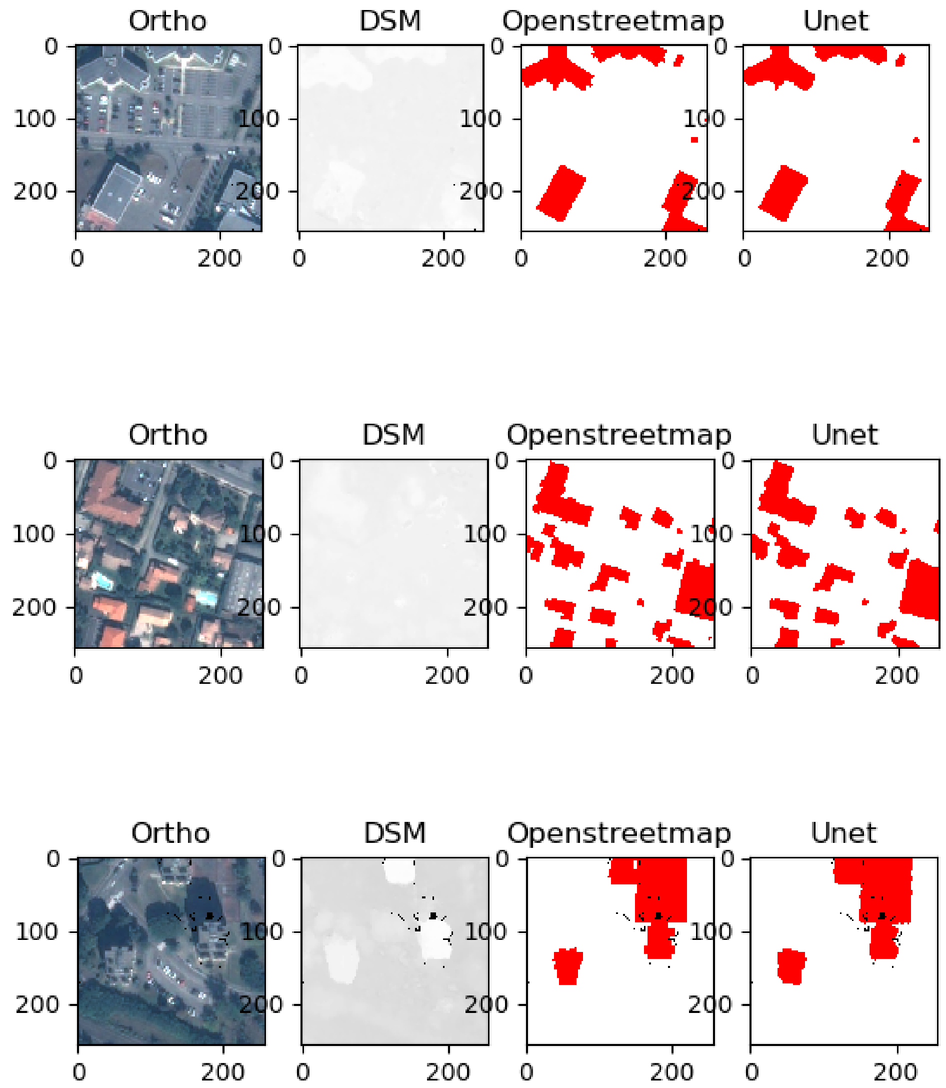


Current performance

- Need to correct manually temporal incoherences between OSM and the ortho.



truth / predicted	building	no building
building	0.97	0.02
no building	0.03	0.98



Perspectives to reach high quality LOD products

- Improve the correlation methods to find corresponding points between stereo images.
  - Existing deep learning methods to find corresponding points
- Noisy DEM products
  - Denoising AI algoritms to remove noise from the optical instrument, atmsopheric perturbations.
- Extrusion of building from classification results
  - Extrusion methods with no artefacts
  - Determination of the average height of detected buildings compared to ground height (DEM vs DTM)
  - Towards the modelization of the roofs (LOD2)
- Determine useful indicators for urban policy

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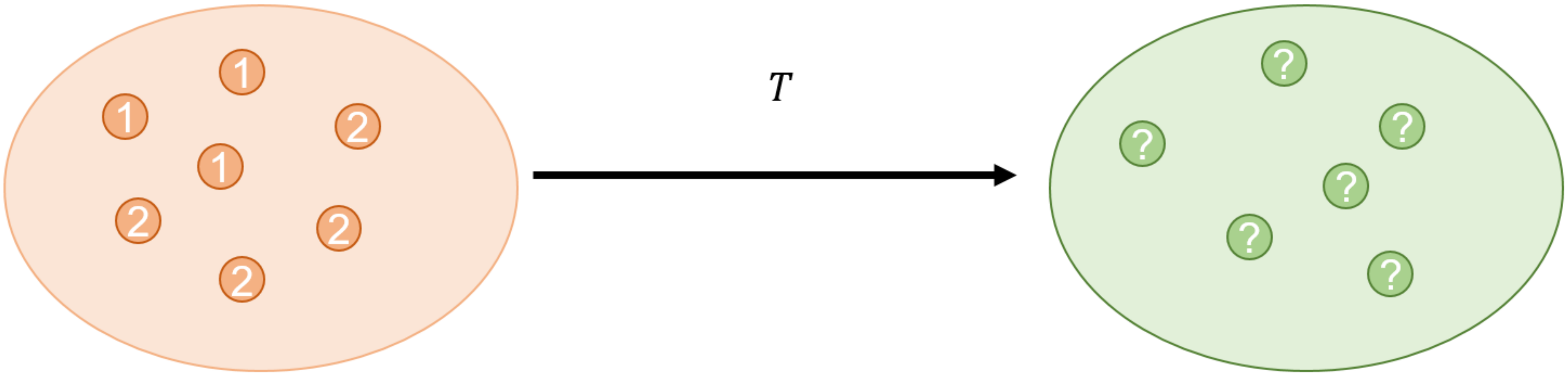
Motivations

- Build predictive model on unlabeled dataset:
  - Historical dataset without ground truth (Spot World Heritage)
  - unlabeled dataset for specific classes (car ground truth available for Pleiades but not for Spot 6)
  - upcoming dataset of a new Earth Observation mission (CO3D)
- Taking full advantage of trained models on a specific dataset:
  - Trained model to detect clouds on Sentinel-2 satellite images
  - Trained model to detect building on 3D data obtained from the processing of S2P to Pleiades satellite images.

Challenges

- PH.D research lead with the research lab IRISA with Claire Voreiter, the company Thales Alenia Space and CNES with the following goals:
  - Labelization of a unlabeled dataset Ω_t from a labeled dataset Ω_s
  - Study the adaptation and the application of optimal transport methods between heterogeneous datasets.
  - Study the performance of a predictive model trained from a transported labeled data
  - Study different use cases of transfer learning for Earth Observation:
    - Car detection
    - 3D building detection
    - Cloud detection

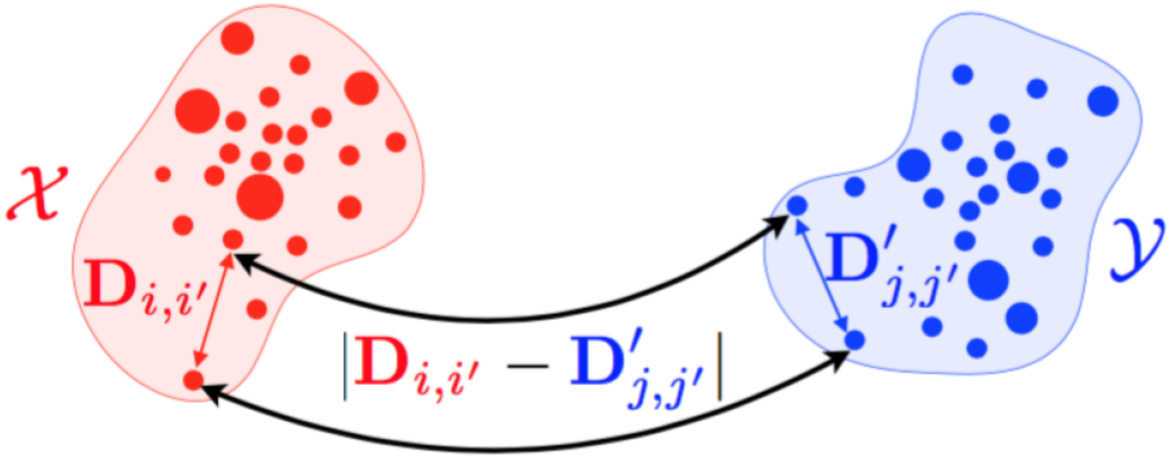


State of art

- Optimal transport method:

$$\min C(T) = \int_{\Omega_s} c(x, T(x))\mu(x)dx$$

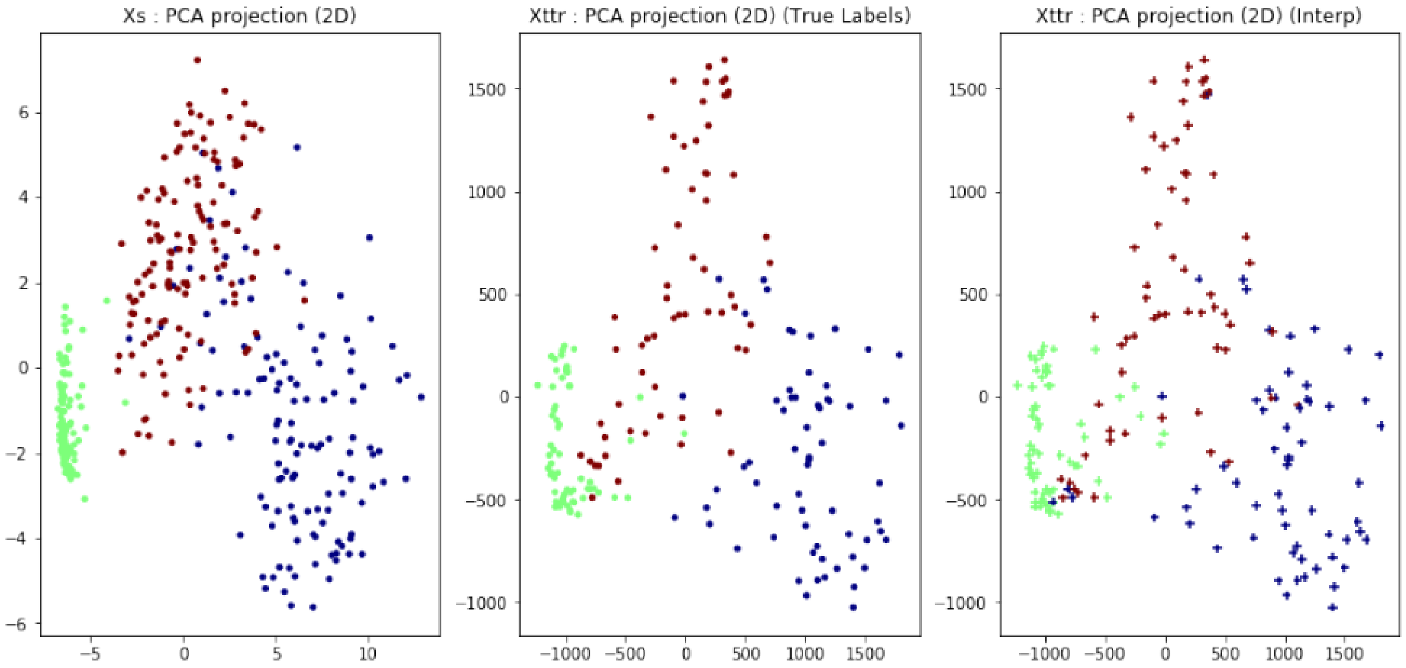
- Use of Gromov Wassertein distance



Transfer learning

First test

- Ω_s: USPC dataset (16 x 16 pixels) with ground truth (classes $\in [0, 2]$)
- Ω_t: MNIST dataset (28 x 28 pixels)
- Experience:
  1. Use of Gromov Wassertein distance to label MNIST dataset from USPC dataset
  2. Visualize the tranported labeled dataset



Perspectives

- Solve the scalability issue when using Gromov Wassertein since it is a quadratic algorithm
- Currently, this method is not relevant for Earth Observation data:
  - Find a way to reduce the dimension and use the Gromov Wassertein in the latent space (AutoEncoder)
- Explore alternative solutions for optimal transport (Generative and Discriminative models)

Thank you for your attention

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